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ENGINEERING AND APPLIED SCIENCE

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Dr. Manijeh Razeghi, Director

June 3, 1996

Dr. Yoon-Soo Park
Office of Naval Research
800 N. Quincy Street
Arlington, VA 22217-5660

**Subject: DURIP Equipment Grant #N00014-95-1-1143
High Vacuum Evaporation System**

Dear Dr. Park:

Please find enclosed three (3) copies of the Final Technical Report for the above referenced DURIP (Defense University Research Instrumentation Program) equipment grant.

Please feel free to contact me if you have any questions, comments, or need additional information.

Best regards,

Manijeh Razeghi
Walter P. Murphy Professor and
Director, Center for Quantum Devices

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13. ABSTRACT (Maximum 200 words) The primary objective of the electron beam evaporator is to apply high quality optical coatings for lasers operating in the midinfrared region (2-5 um) band, as well as lasers emitting in the range of 0.7 um - 1.0 um wavelength. The electron beam evaporator is used to compare the performance of midinfrared laser diodes with different schemes of optical coating on the laser facets. The use of optical coatings on lasers facets is to show the improvement in high power performance with HR (high reflective) + LR (low reflective) coating, and high temperature performance with HR coatings for the midinfrared lasers as well as lasers emitting in the range of 0.7 um - 1.0 um. It has become mandatory to use high quality optical coatings for further improving the performance of 3.2 um InAsSb/InAs lasers. Three schemes of facet coatings are studied: LR coating on front, HR on back, and asymmetric coating of LR/HR. The ebeam system is also used for the application of Sb-based infrared photodetectors.				
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Summary Report of Electron-Beam Evaporator

Since the delivery of the electron beam evaporator to the center on November/December 1995, the system has been under maintenance for approximately 3-4 months. Upon replacing numerous electrical parts of the system, the operation of the system is satisfied. At present the e-beam system is under processing optimization since March of 1996. The primary objective of the electron beam evaporator is to apply high quality optical coatings for lasers operating in the midinfrared region (2 - 5 μm) band, as well as lasers emitting in the range of 0.7 μm - 1.0 μm wavelength.

The electron beam evaporator is currently being used to compare the performance of midinfrared laser diodes with different schemes of optical coating on the laser facets. Several film coatings are presently being investigated such as SiO_2/Au , and SiN_4 for low reflective (LR) coating and 1/4 stacks of $\text{Si}/\text{Al}_2\text{O}_3$ for high reflective (HR) coating. The use of optical coatings on laser facets is to show the improvement in high power performance with HR + LR coating, and high temperature performance with HR coatings for the midinfrared lasers as well as lasers emitting in range of 0.7 μm - 1.0 μm . As the device structures and fabrication techniques are being optimized for the 3.2 μm InAsSb/InAs lasers; it has become mandatory to use high quality optical coatings for further improving the performance.

Three schemes of facet coatings is experimentally being studied at this time: LR coating on front, HR on back, and asymmetric coating of LR/HR on front and back facet respectively. Such studies requires stable and optimum performance of the coating system which includes precise thicknesses and refractive index of the coatings. The estimated time to obtain optimum performance of coating is within 5 - 8 months. Emphasis is given to the quantitative measurements of reflectivities and these are compared with the calculated performances of the coating.

The coating **ebeam** system is also currently being used for the application of Sb-based infrared photodetectors. The Sb-based infrared photodetectors on Si and GaAs substrates have been demonstrated without the use of passivation. The peak detectivity of InSb photodetectors on Si for 5 μm is $3 \times 10^{10} \text{ cm} \cdot \text{Hz}^{1/2} \text{ W}$ at 77K. The corresponding detector area of the device was $400 \times 400 \mu\text{m}^2$. In order to develop a two-dimensional detector arrays and focal plane arrays, it is necessary to reduce detector size at least smaller than $60 \times 60 \mu\text{m}^2$. However, surface leakage becomes more significant at low temperatures. Furthermore, wire bonding directly on InSb epitaxial layers damages the surface, which

leads to more surface leakages. In order to reduce surface leakage, SiO_2 as a surface passivation is necessary to suppress the trap density from the surface. In parallel, the off-sensitive bonding can be realized so that the bonding-damage can be avoided. The fabrication of Sb-based infrared photodetectors with SiO_2 is currently being experimented with the e-beam coating system as well. Surface passivation is of prime importance for developing high quality photodetectors, and detector arrays for focal plane arrays.